# SESAME STORAGE RING RF-SYSTEM

**Darweesh FOUDEH on behalf of RF Group:**

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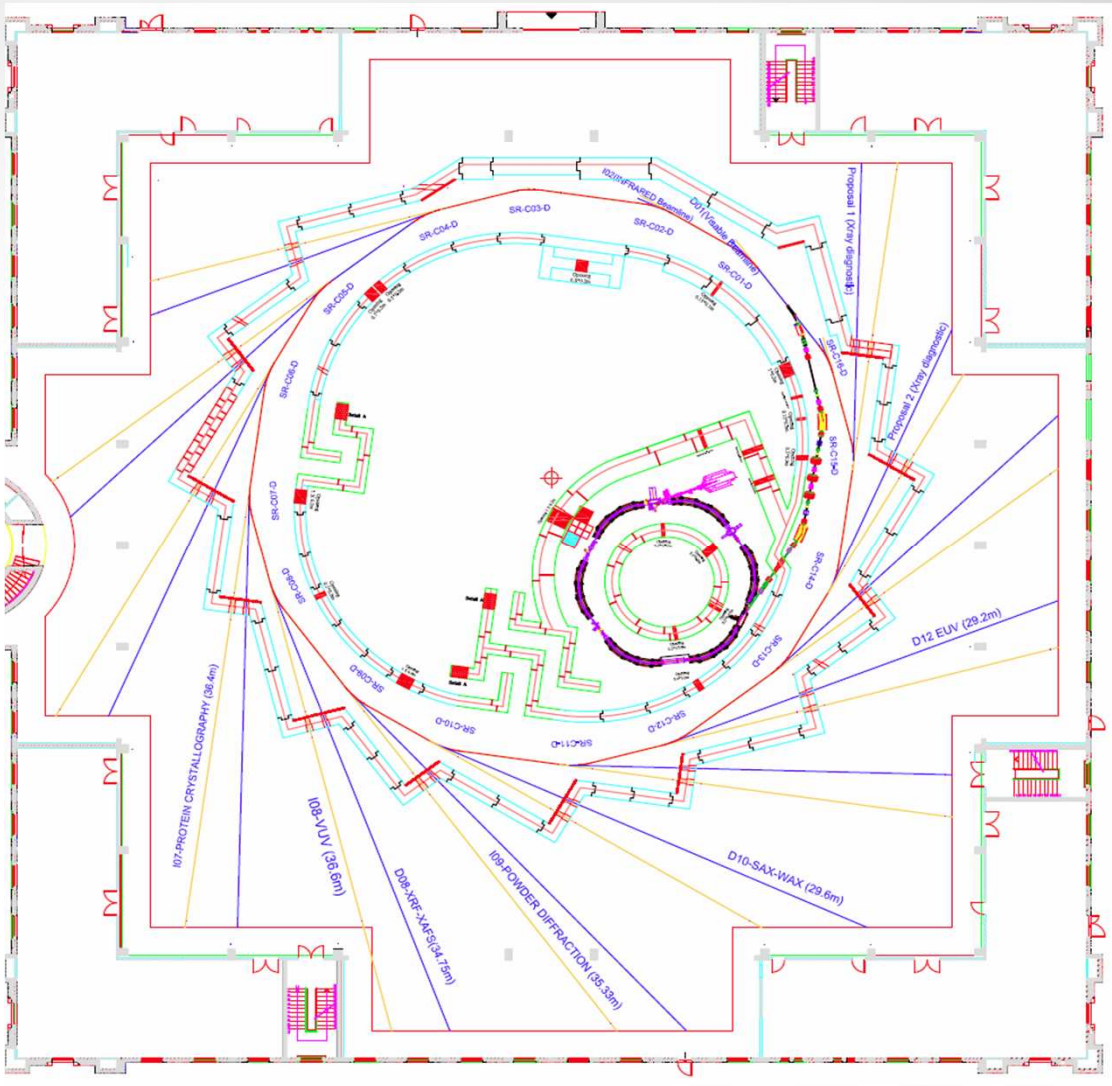
**2- Ala' Kurdi.**

# SESAME SR MAIN PARAMETERS

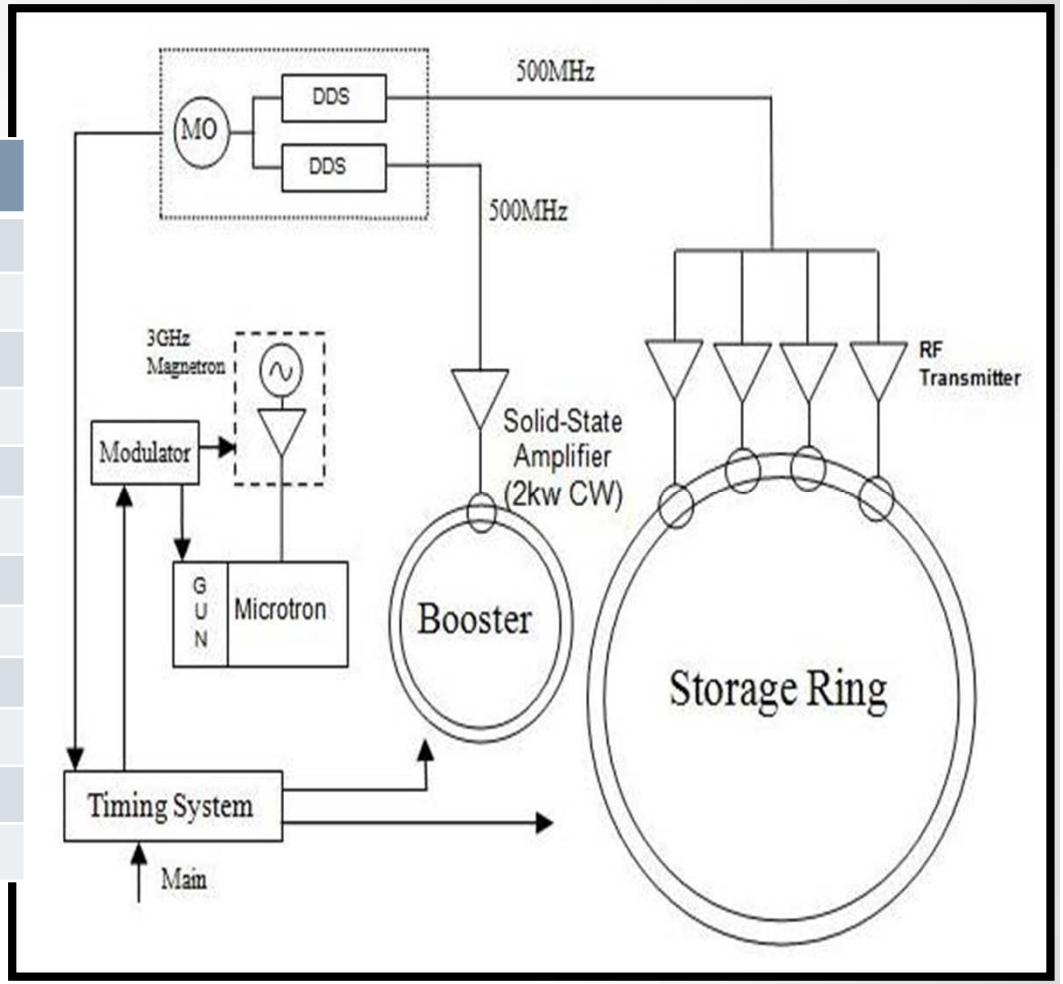
| Parameter | Value |
|---|---|
| Energy | 2.5 GeV |
| Circumference | 133.20 m |
| Super Periods # | 8 |
| Bending Dipole | 1.45545 T |
| Radiation loss/turn | 590 KeV |
| Beam current | 400 mA |
| Beam power loss | 236 kW |
| Harmonic number | 222 |
| Mom. Comp. factor | 0.00828 |
| Energy acceptance | 1.45 % |
| Nat. Emittance $\varepsilon_x$ / $\varepsilon_z$ | 25.74/0.2574 |
| Energy Spread rms | 0.1073% |
| Beam Lifetime | 21.5h |




SESAME Machine

# SESAME RF Layout and Main Parameters

| Parameter | Booster | Storage ring |
|---|---|---|
| RF frequency | 499.654MHz | 499.654MHz |
| Total RF Voltage | <100KV | 2.42MV |
| Harmonic number | 64 | 22 |
| Circumference | 38.4 m | 133.20 m |
| RF Acceptance | | 1.463 % |
| Synchronous phase | 170º | 165.5º |
| Synchrotron Tune | | 0.0165 |
| Synchrotron Freq. | | 37.147KHz |
| Nat. Bunch Length | | 11.42mm |
| Revolution freq. | 7.807MHz | 2.25 MHz |
| RF wavelength | 0.600 m | 0.600 m |
| Coincidence freq. | 70.334 KHz | |



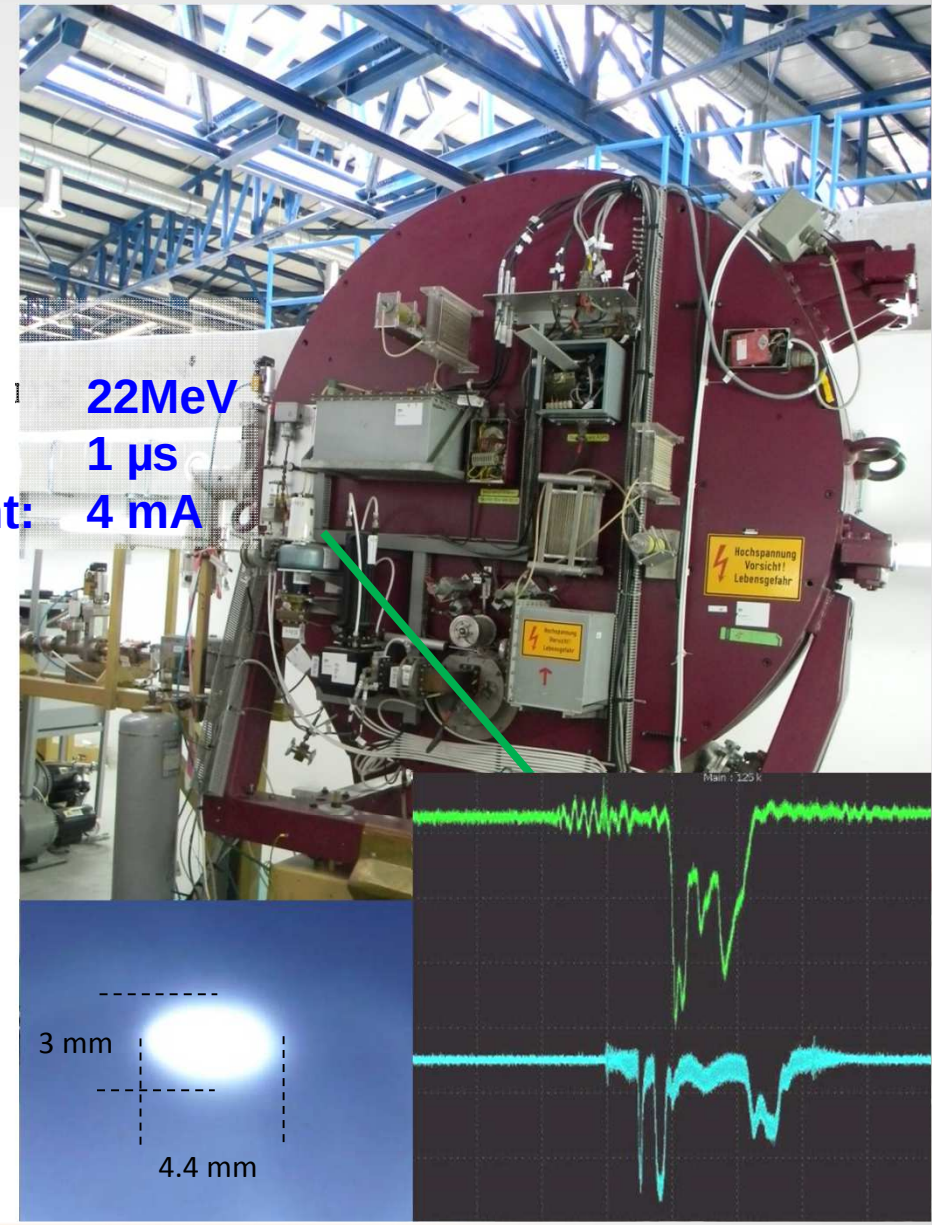

SESAME Injector
And Booster

# MICROTRON INJECTOR RF

| | | |
|---|---|---|
| **Magnet Field:** | **0.112** | **T** |
| **Diameter:** | **2.22** | **m** |
| **Energy gain/turn:** | **0.535** | **MeV** |
| **Max. e-Radius:** | **0.67** | **m** |
| **No turns:** | **42** | |
| **RF frequency:** | **3.00** | **GHz** |
| **RF-Peak-Power:** | **2** | **MW** |

**Achieved:**

| | |
|---|---|
| **Energy:** | **22MeV** |
| **Pulse-Width:** | **1 µs** |
| **Pulse-Current:** | **4 mA** |



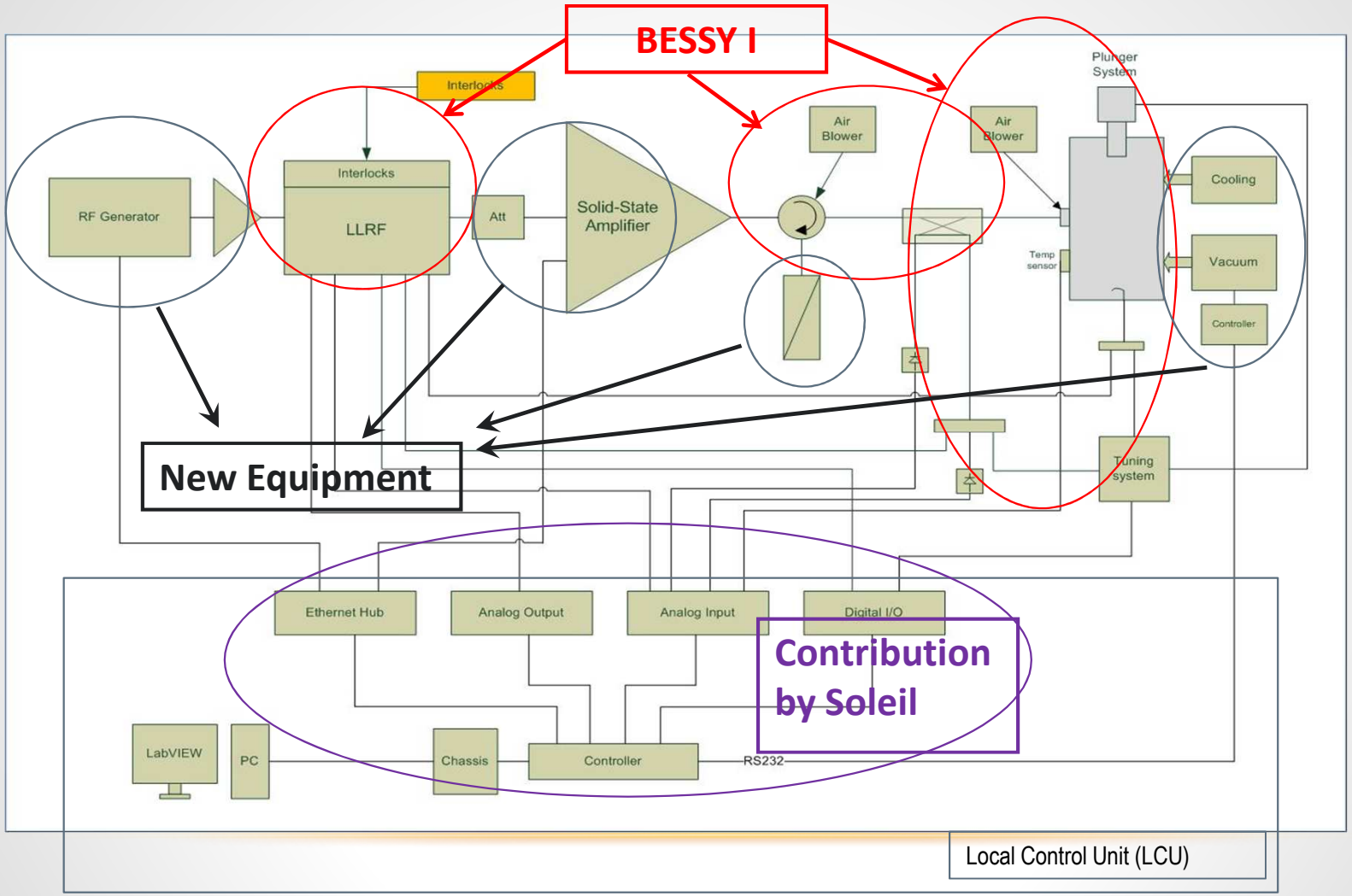

The main upgrades in the near future are:

- To change the old DC motors to stepper type.
- Replacing the old modulator with SS System.

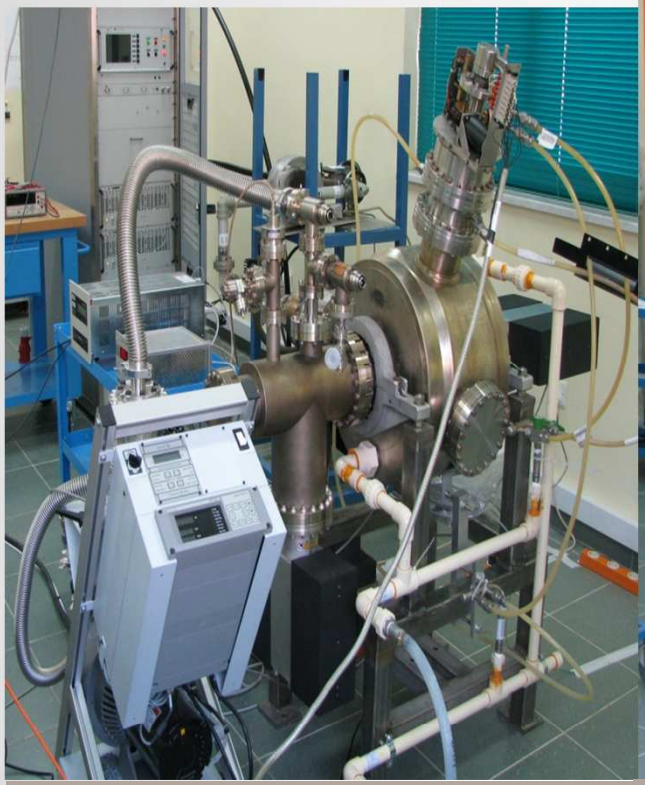
A possibility to replace to whole u-Tron with new 50MeV race track u-Tron.


SESAME Injector
And Booster

# SESAME Booster RF Plant and Lab Local Control



# SESAME Booster RF Plant at Lab

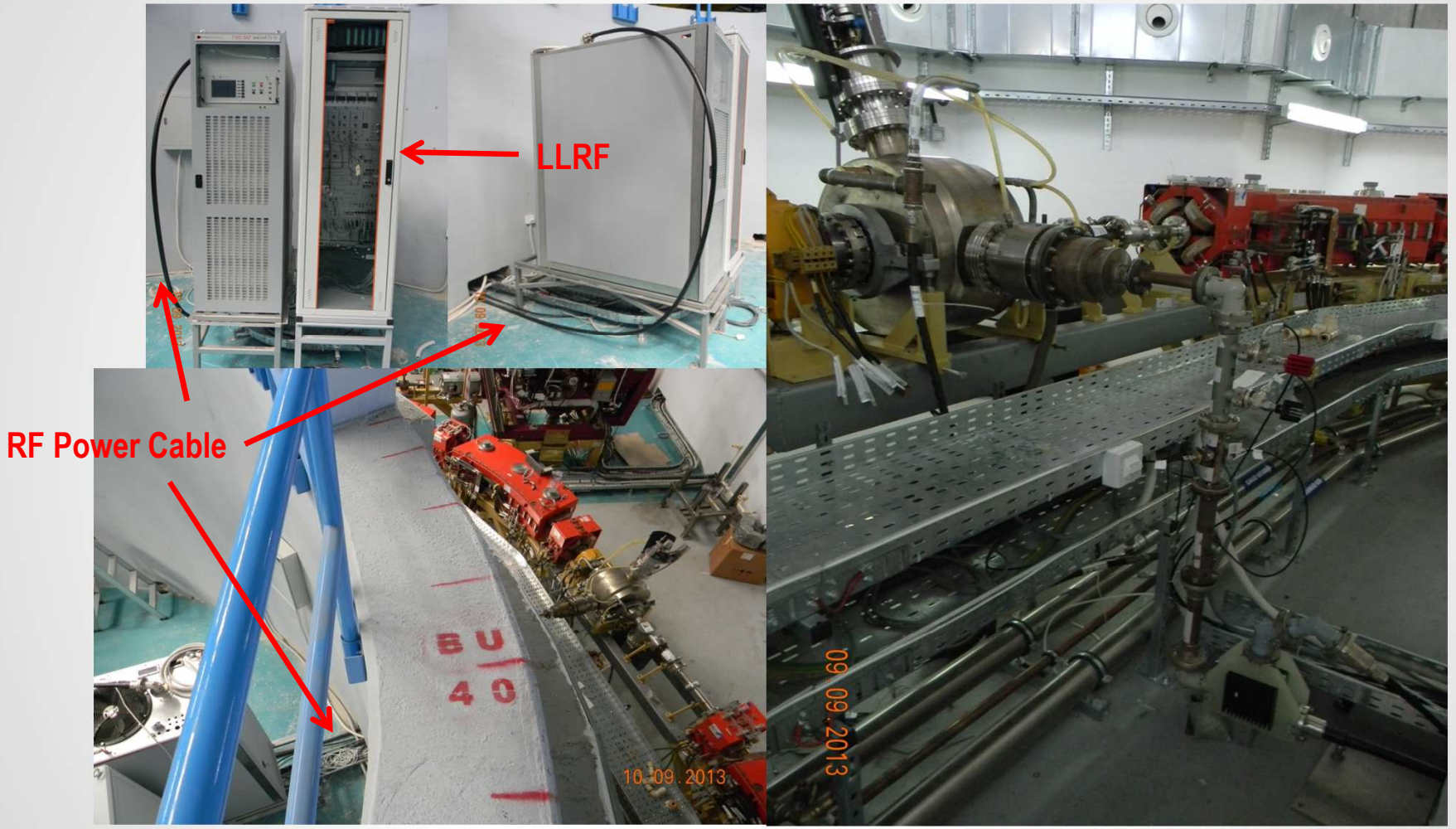


Booster 2KW RF Cavity (BESSY1)

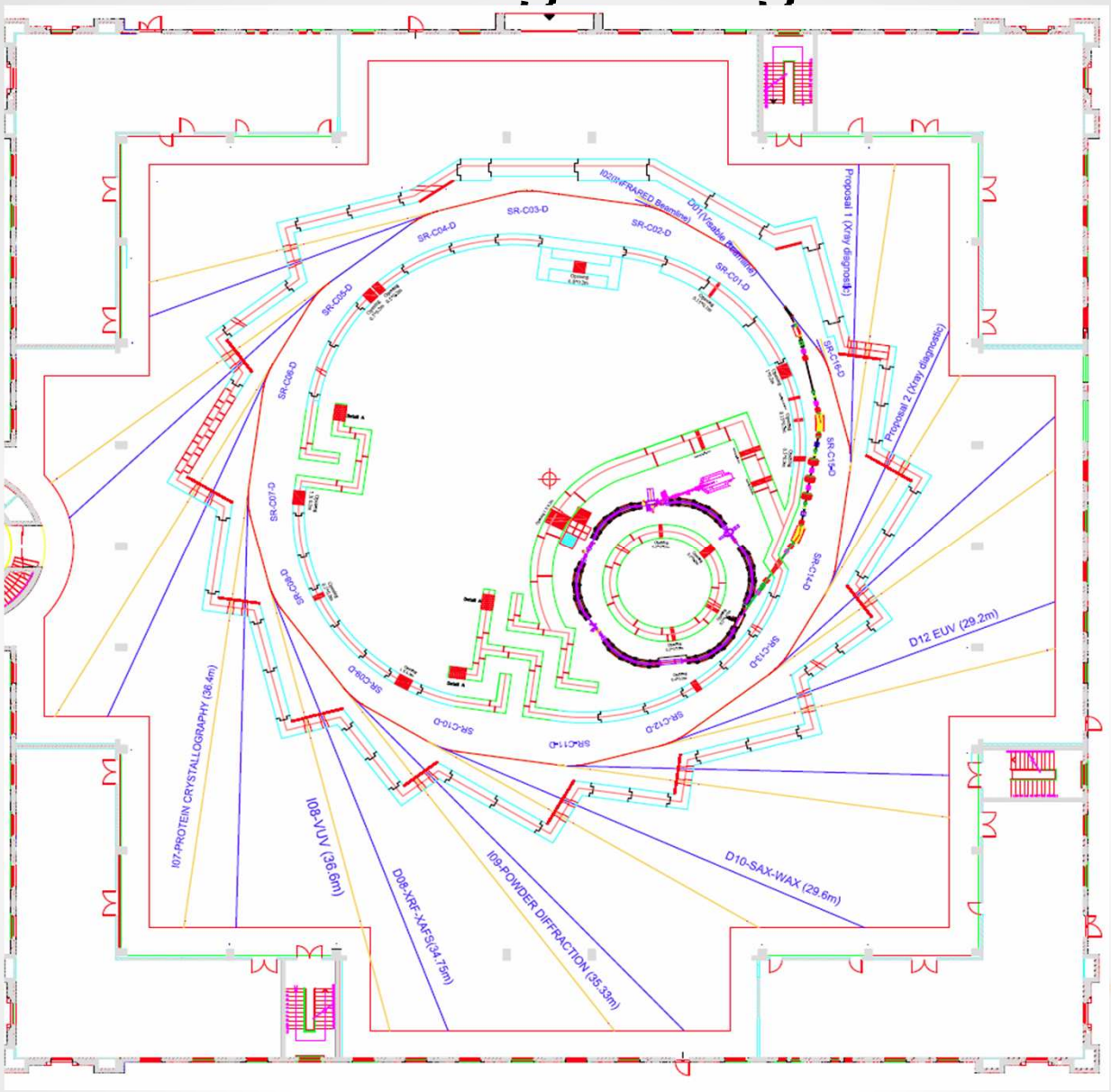
Booster LLRF (BESSY1) tested in the RF lab


The new 2kW Solid-State amplifier as replacement for the old klystron used in BESSY1

# RF Plant Installed



# Storage Ring



# FINANCIAL ASPECTS TILL 2016

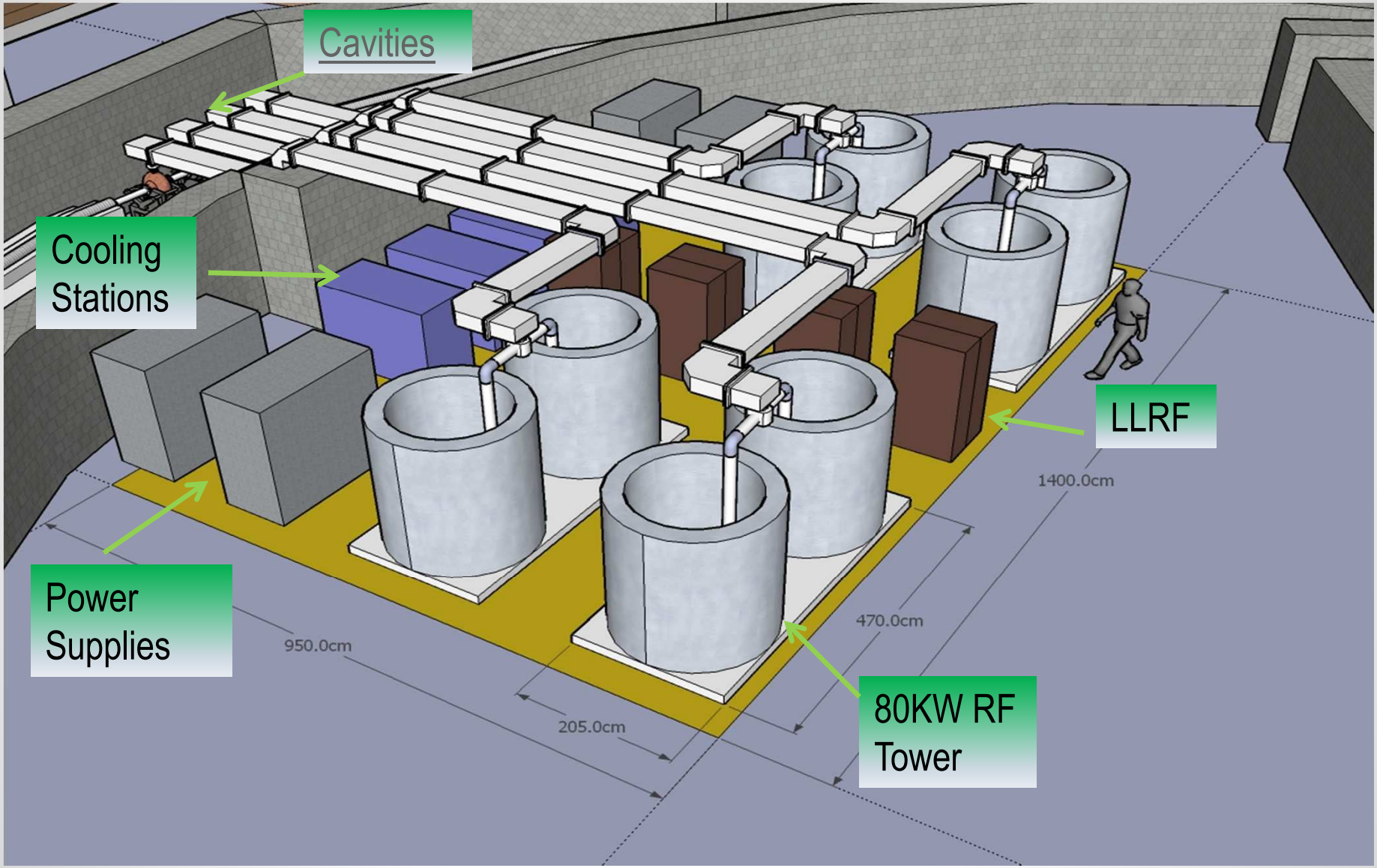
Income

EU-CERN: 5.00 M€
Jordan: 4 x 1.25 M$
Turkey: 4 x 1.25 M$
Israel: 4 x 1.25 M$
Iran: 4 x 1.25 M$ ?
Pakistan: in kind contribution?
USA?
Norwegian?

| | |
|---|---|
| Machine: | **25.6 M$** |
| 4 Beam-lines upgrade: | **8.7 M$** |
| Guesthouse+ | **1.3 M$** |
| Sum | **35.6 M$** |

| | |
|---|---|
| Injector-upgrade | 0.9 M€ |
| **Magnets and PS:** | **5.0 M€** |
| Girder: | 0.8 M€ |
| **Vacuum:** | **3.0 M€** |
| **RF:** | **3.0 M€** |
| Diagnostics: | 1.5 M€ |
| SR-Cooling: | 0.5 M€ |
| Cabling: | 0.5 M€ |
| Commissioning: | 1.5 M€ |
| Control-System | 1.1 M€ |
| Safety P+A | 0.8 M€ |
| Front-Ends: | 0.5 M€ |
| Sum [€] | 19.0 M€ |
| Sum [$] | 23.3 M$ |
| +10% | **25.6 M$** |

# SR RF PLANTS


Cavities
Cooling Stations
LLRF
Power Supplies
80KW RF Tower
1400.0cm
950.0cm
470.0cm
205.0cm

# SESAME Collaborations

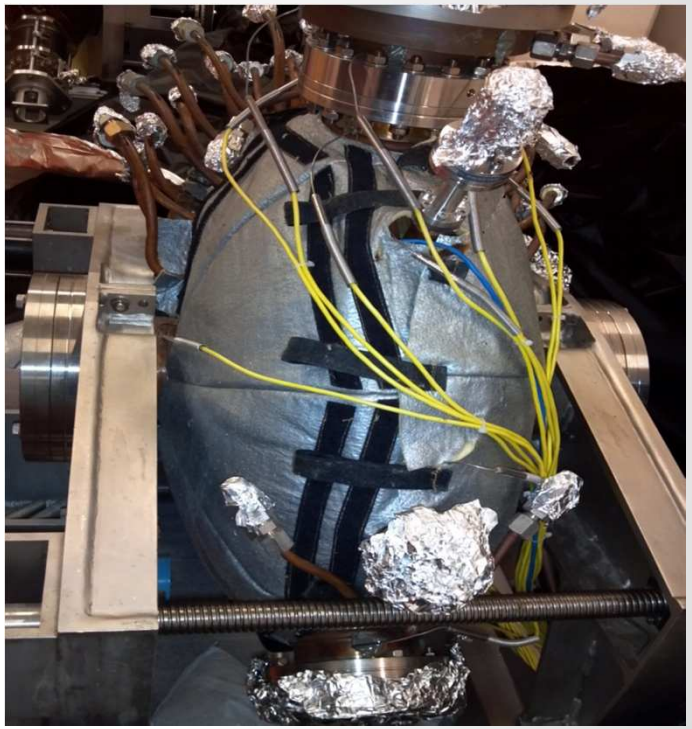
## SESAME-Elettra Collaboration:

1. The first MOU had been signed with Elettra who donated two 60KW Elettra cavities for the commissioning of the SESAME SR.
2. Recently; the Italian government declared about the intension to help SESAME with in-kind contribution of about 1M EU which possibly is subject to increase in the future.

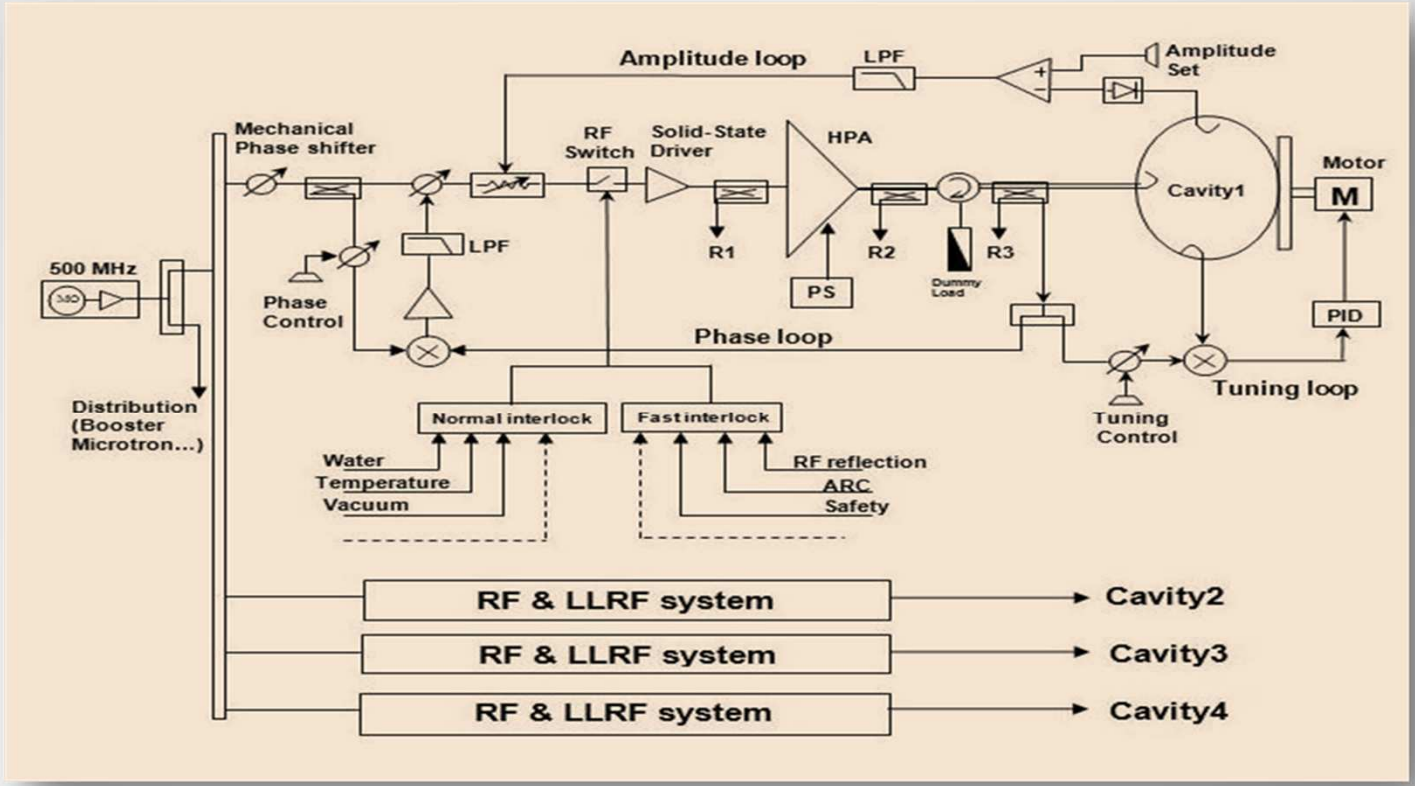
## SESAME-SOLEIL Collaboration:

1. The second MOU had been signed with SOLEIL to build the SSA for SESAME SR.
2. SOLEIL had helped in many aspects SESAME, ie; alignment, power supplies, control…etc.
3. The two Elettra cavities had been sent first to SOLEIL to make the required tests and to use it as a load for the SSA.
4. After finishing the preliminary tests one of the cavities will be sent to Tom-X project to install it in the ring and test its performance up to the time it will be needed at SESAME.

Other collaborations are being worked on for the future

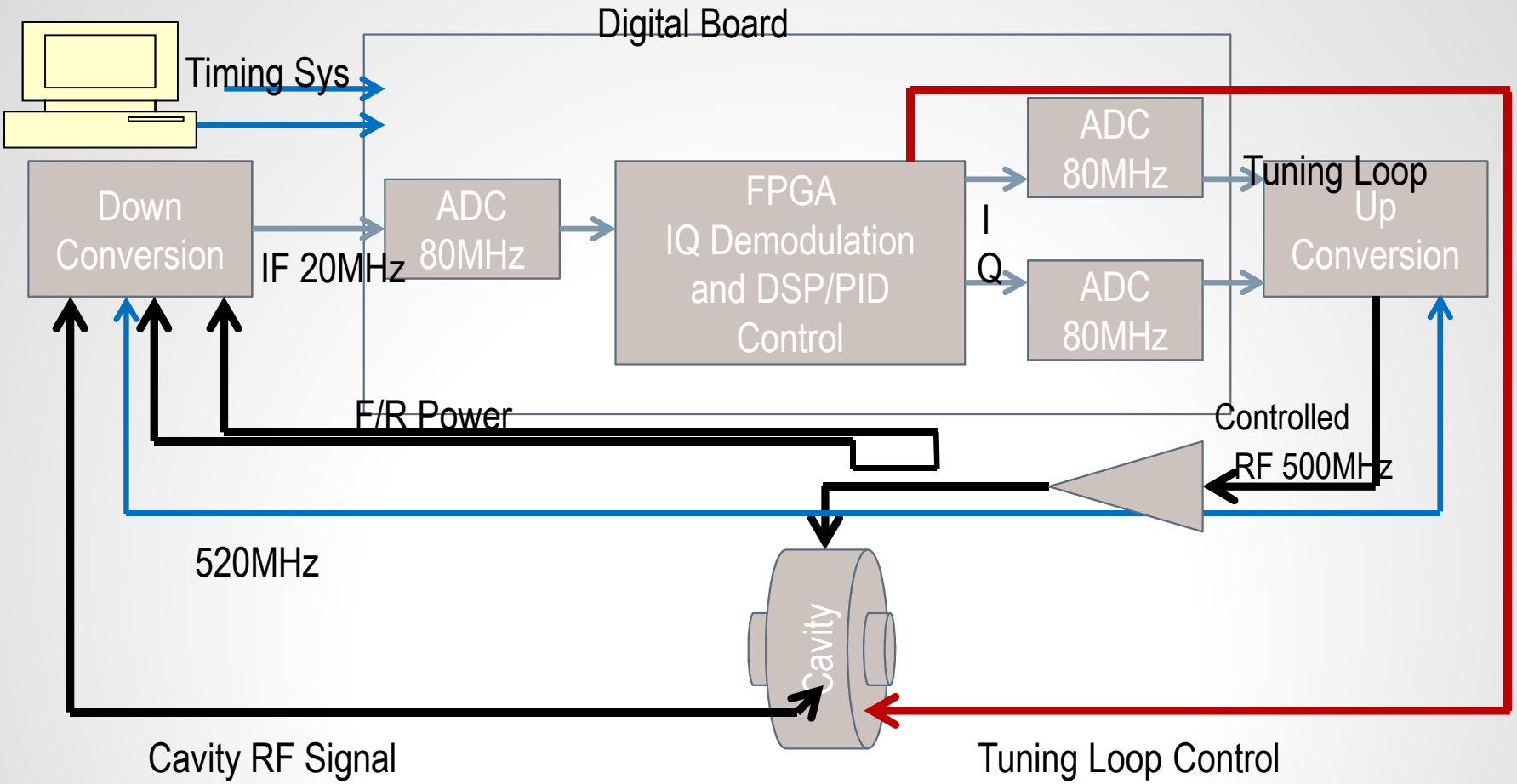


# SESAME SR RF SYSTEM GENERAL LAYOUT




- So far, the above analog LLRF had been adapted for the Storage Ring.
- As a strong alternative, a digital LLRF for the Storage Ring RF system will be adapted.
- A proposal for establishing a collaboration between ALBA & SESAME to help in building the SESAME DLLRF.

# Simplified DLLRF for SESAME RF Plant



# SESAME SR RF Power Amplifier

In the early design stages SESAME has adapted the SSA technology instead of vacuum tubes due to:

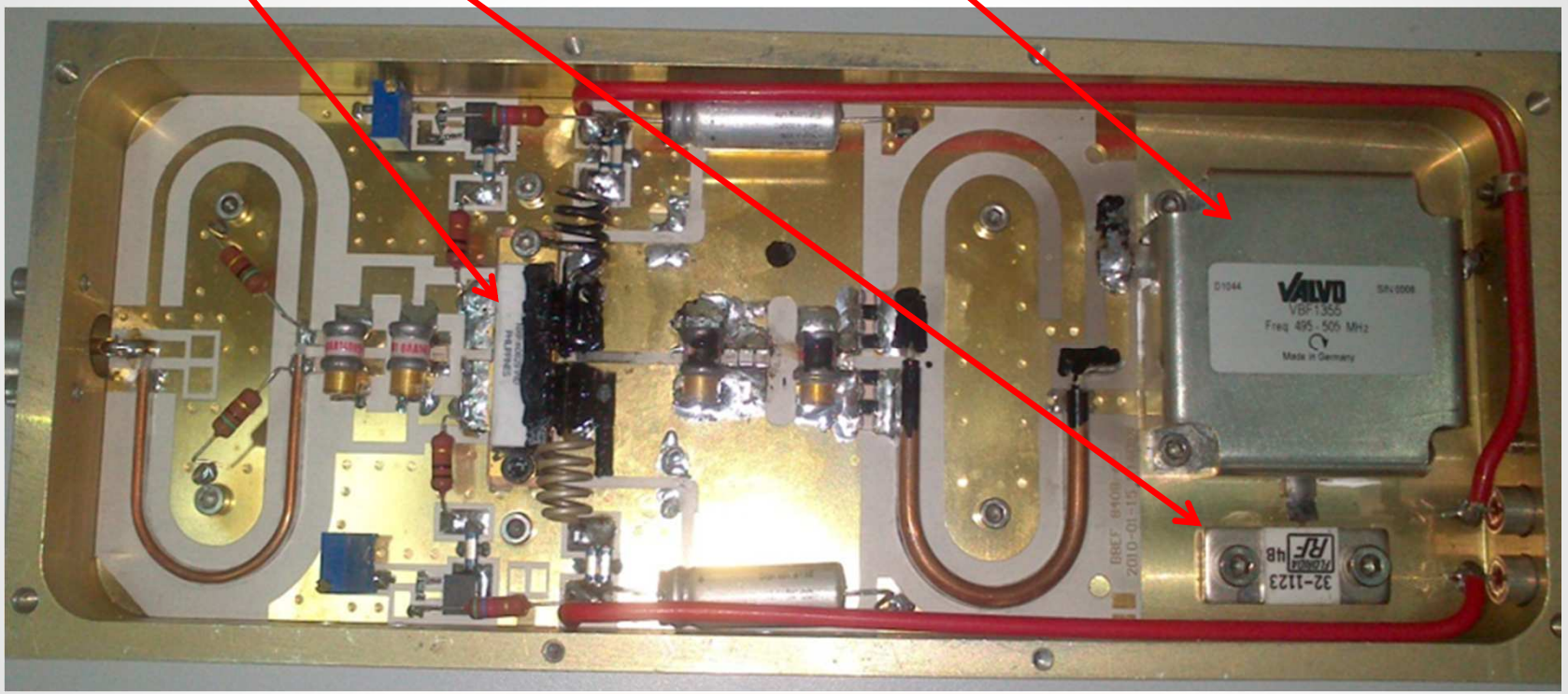
- absence of high biasing voltages.
- longer life times.
- stable gain with aging.
- easier and quicker maintenance and no machine interruption.
- possibility of reduced power operation in case of failure.

SOLEIL SSA module had been adapted as the main block for building the amplifier tower based on the LDMOS BLF578XR transistors from NXP Semiconductors.

| BLF578XR | | | | |
|---|---|---|---|---|
| BW MHz | $P_L$ | VSWR @ 225MHz P.Oper & $P_L$ 1200W; 1400 | Gain | $\eta_D$ % |
| 10-500 | 1200 | 13:1 | 24dB | 70 |
| 10-500 | 1400 | 65:1 | 23.5 | 69 |

SESAME SSA main block showing:

- Power transistor with the surrounding matching circuits.
- 2KW circulator on the output with (495-505) MHz BW.
- 2KW dummy load.



SESAME SSA main module tests.

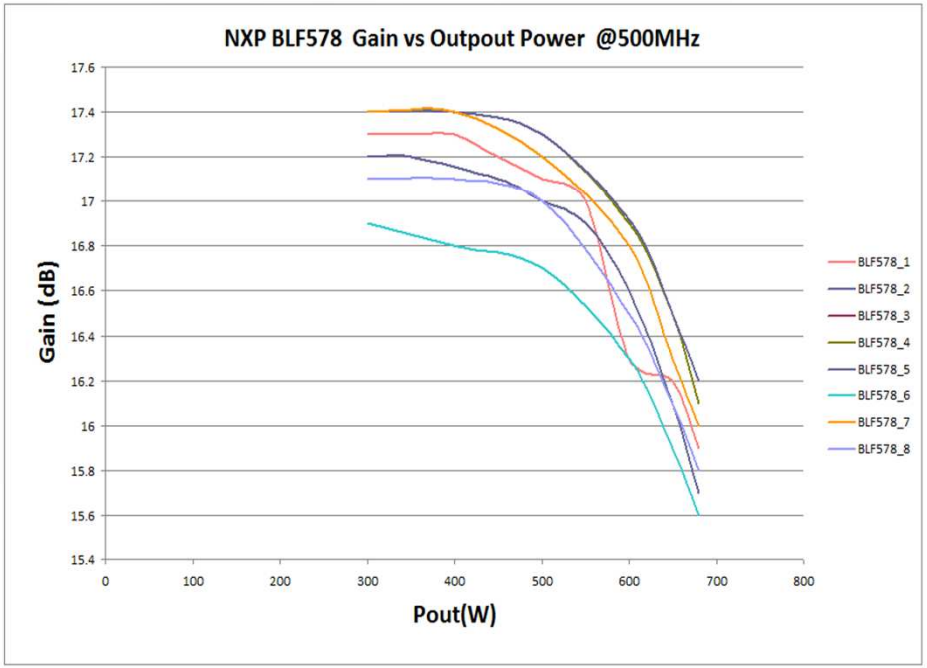
- Two colleagues from the RF group had visited SOLEIL to do all required tests.
- Phase1 tests were based on testing each module by itself, two groups of the module were identified, one is using the BLF578 x 8 and the other is using BLF578XR x 6.
- Phase2 tests were made for the whole group as one amplifier.
- Phase3 tests were made by combining the two groups.

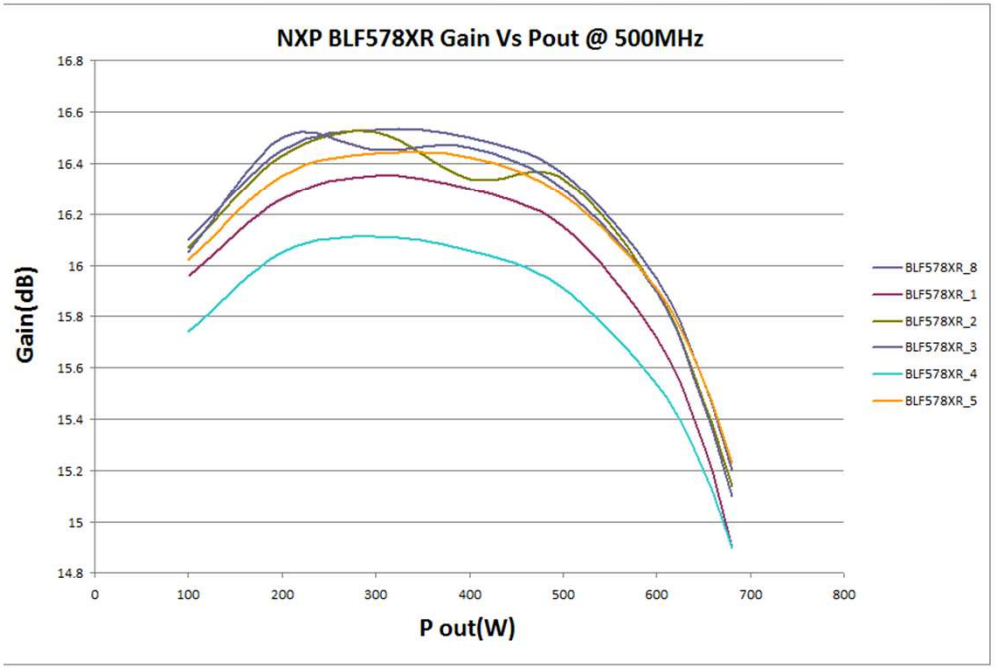
The reference output level for each module was 650W@500MHz for both groups.

| BLF578 Module | | | | | | BLF578XR Module | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissipated Power W | $S_{11}$ dB | Gain dB | $\eta$ % | $\Delta\eta$ % | Phase Shift | Dissipated Power W | $S_{11}$ dB | Gain dB | $\eta$ % | $\Delta\eta$ % | Phase Shift |
| 380 | -50 | 16.3 | 63 | 3.2 | 25° | 517 | -54 | 15.4 | 55 | 1.8 | -31° |

# Gain vs. Pout for each module

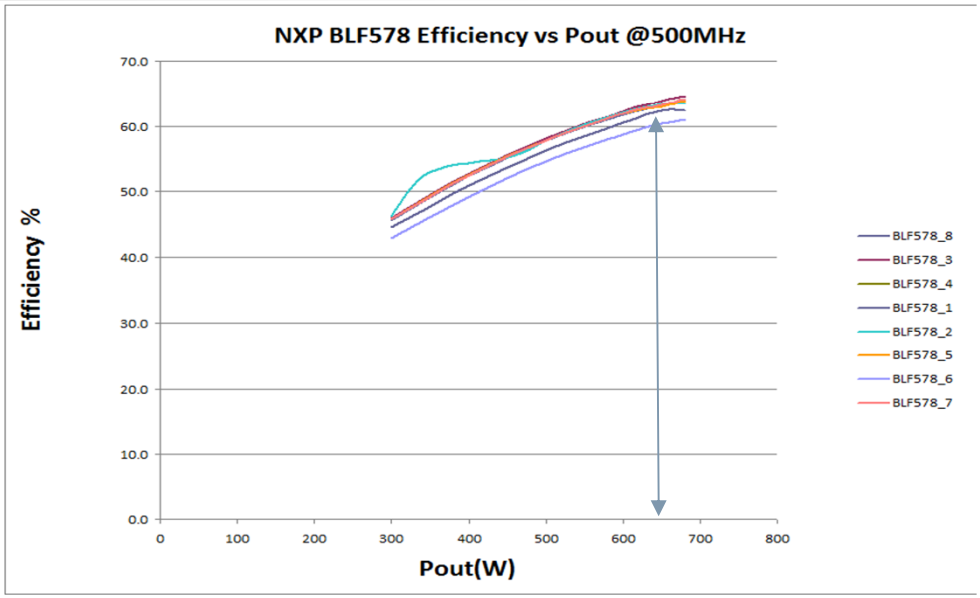
- BLF578: 16.3 dB
- BLF578XR: 15.4

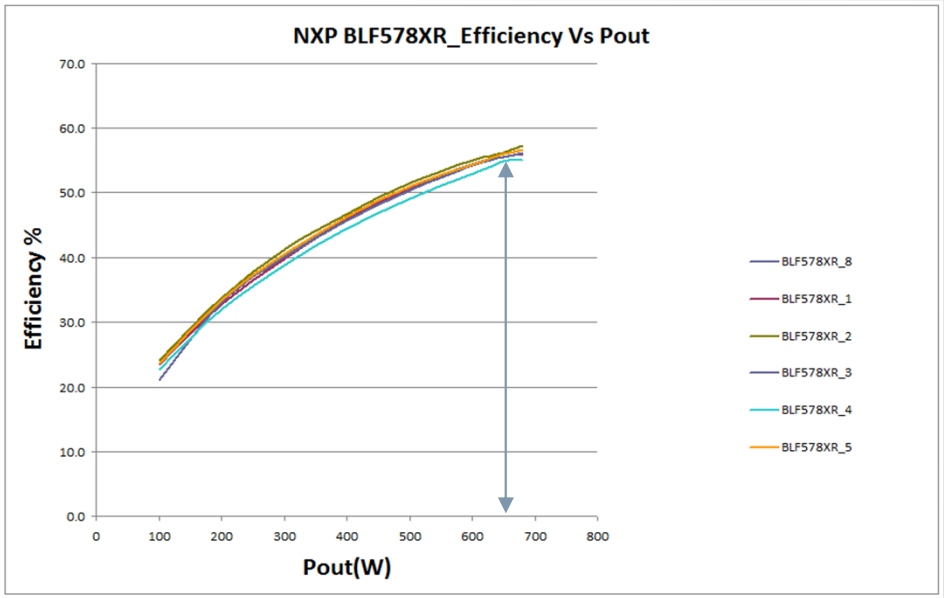


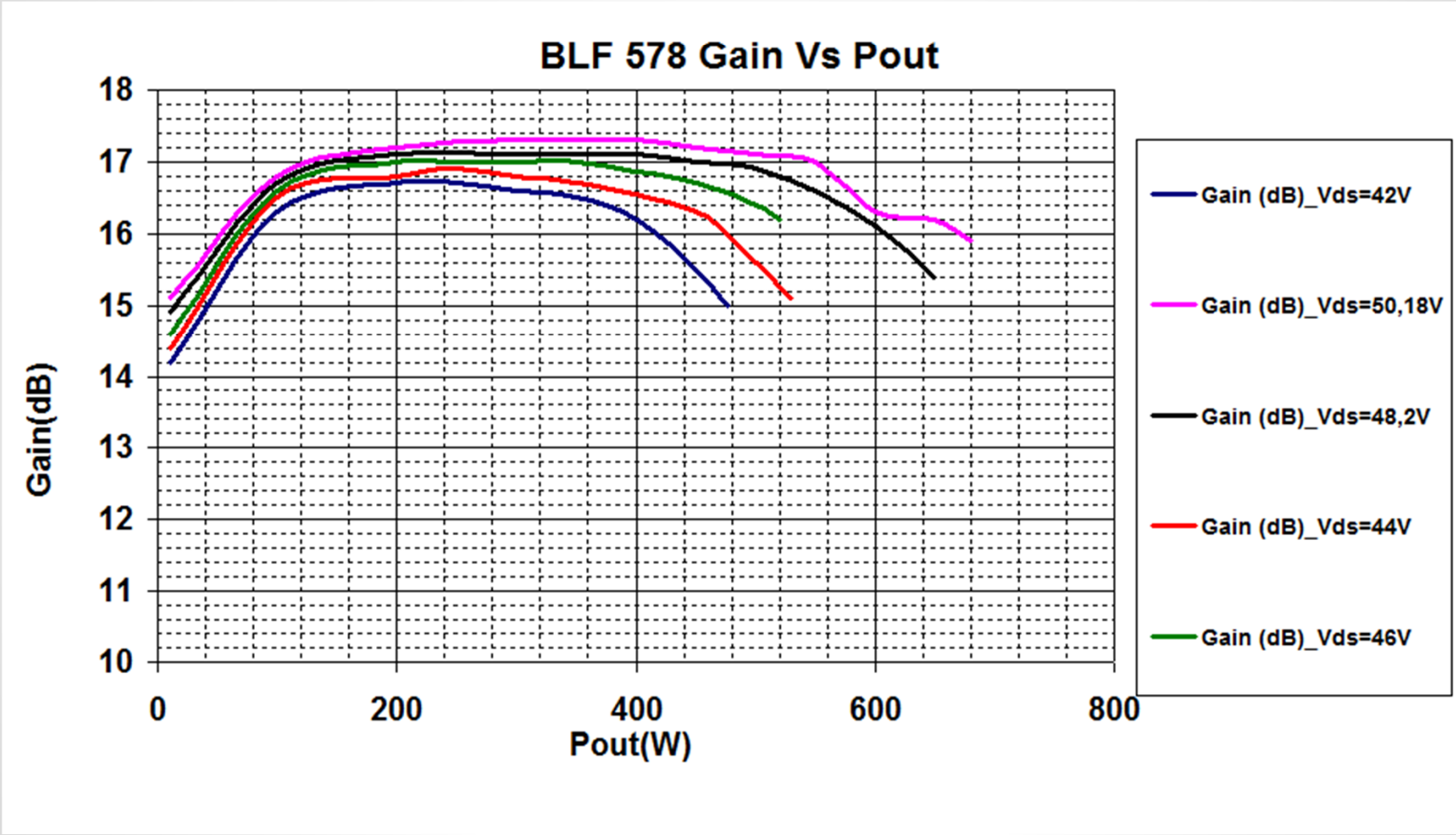
# Efficiency vs. Pout

- BLF578: 63%.
- BLF578XR: 55%.

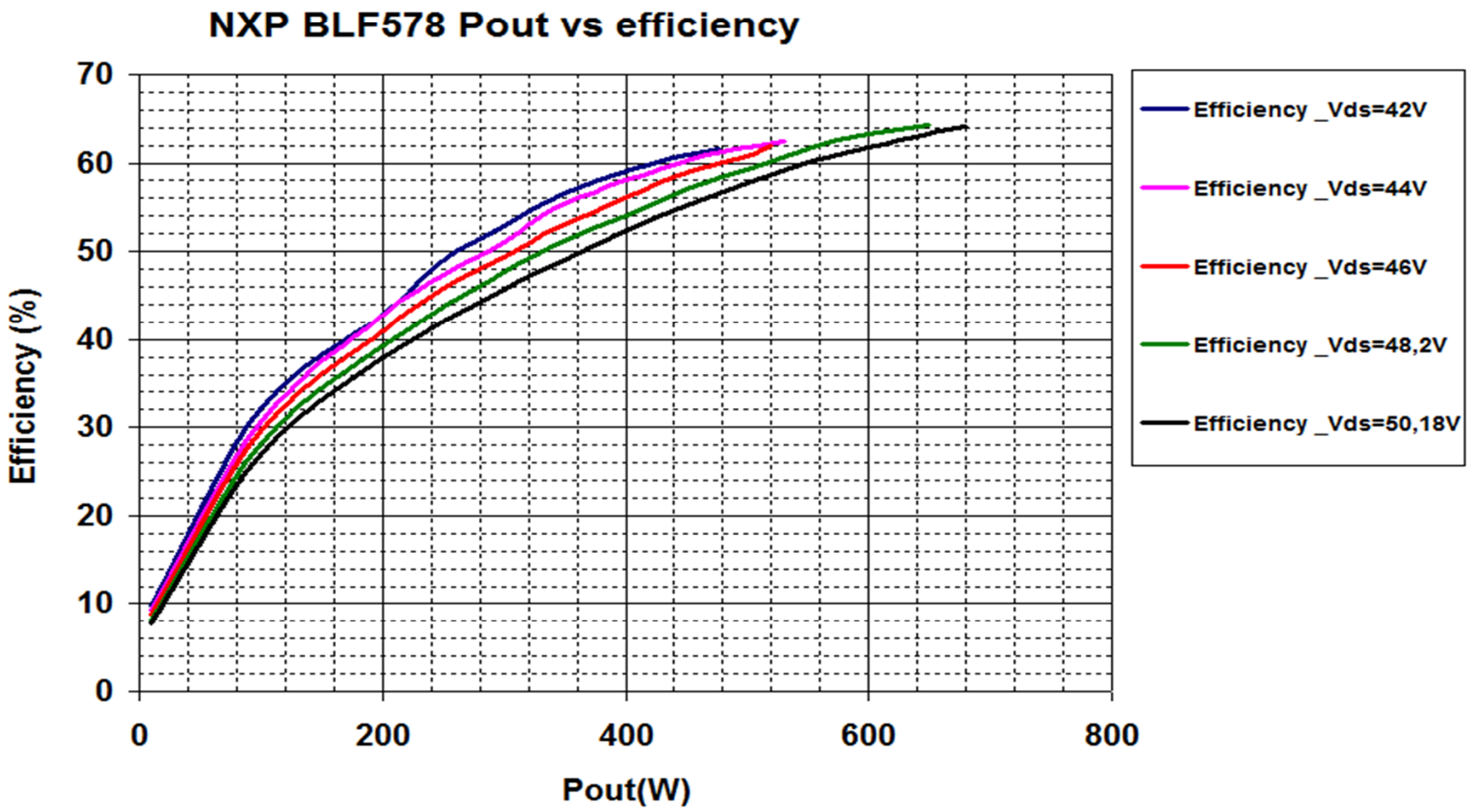


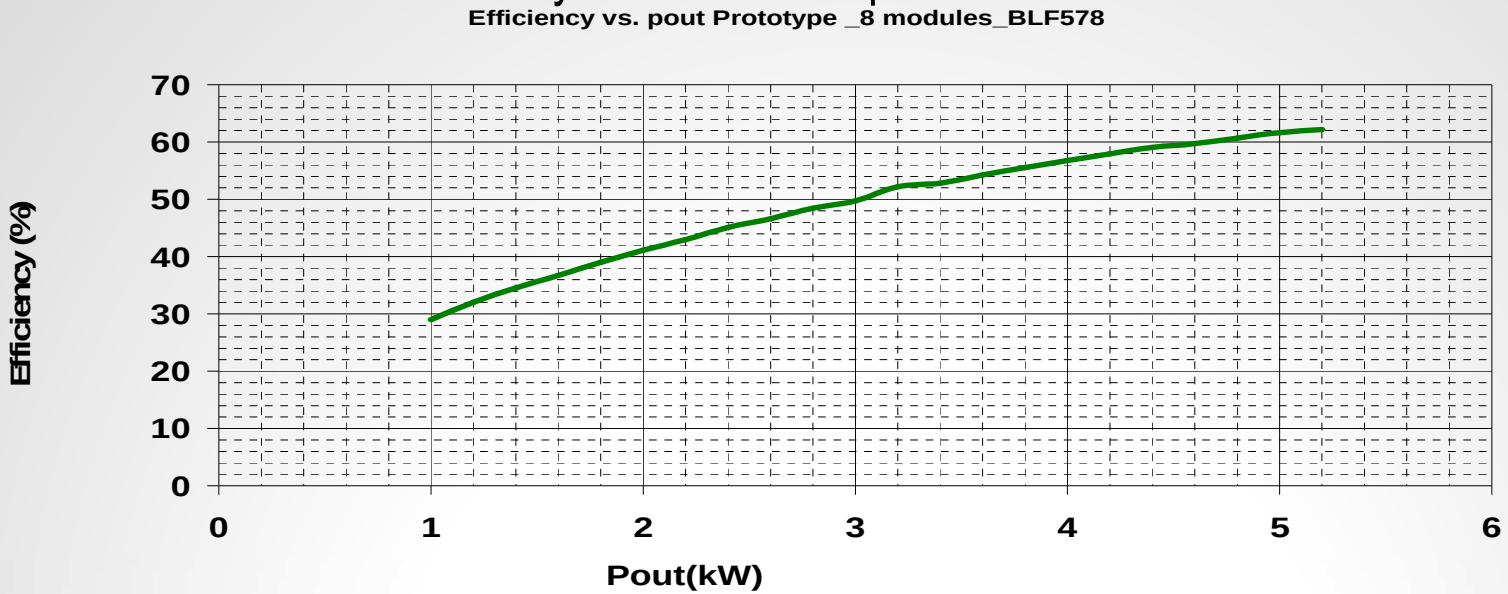
# Module BLF578#1 gain tests with respect to $V_{DS}$ voltage

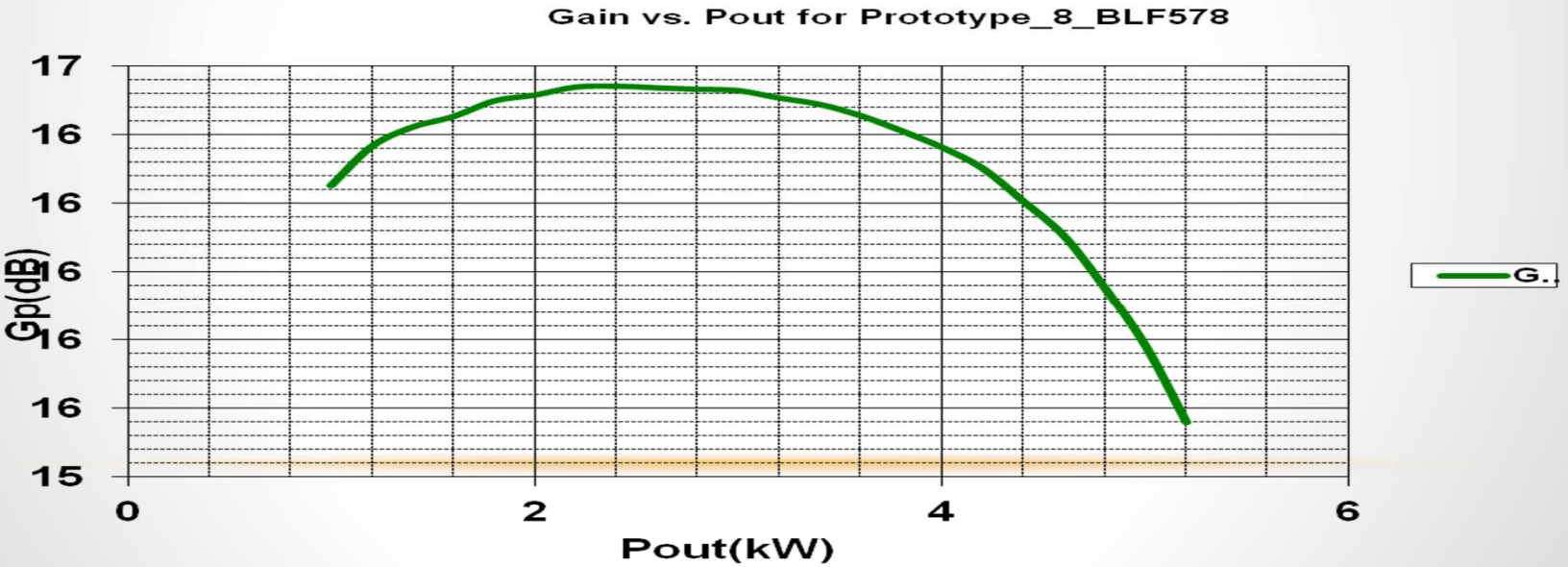


# Module BLF6578#1 efficiency tests with respect to $V_{DS}$ voltage

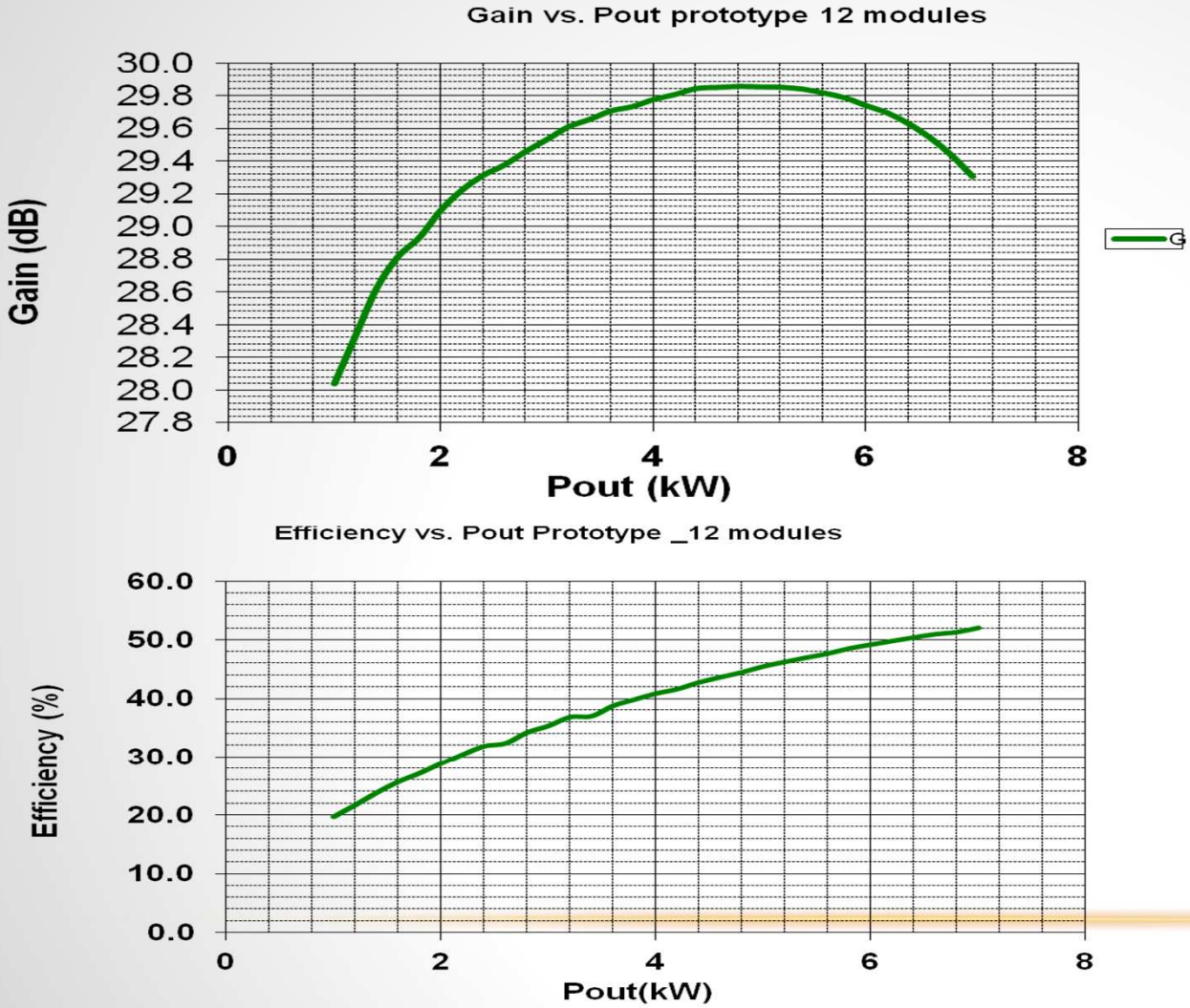


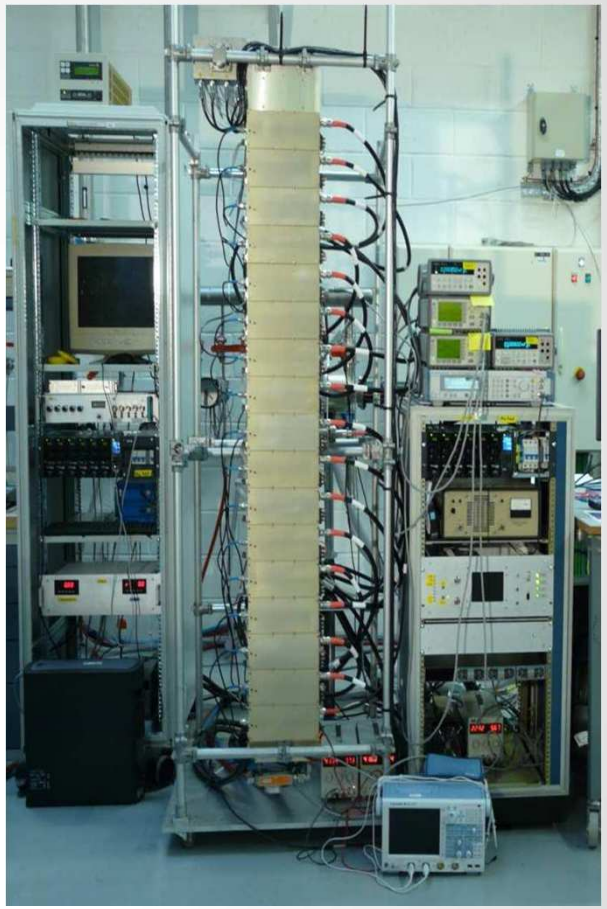
# Gain & Efficiency vs. combined power of the BLF578 modules

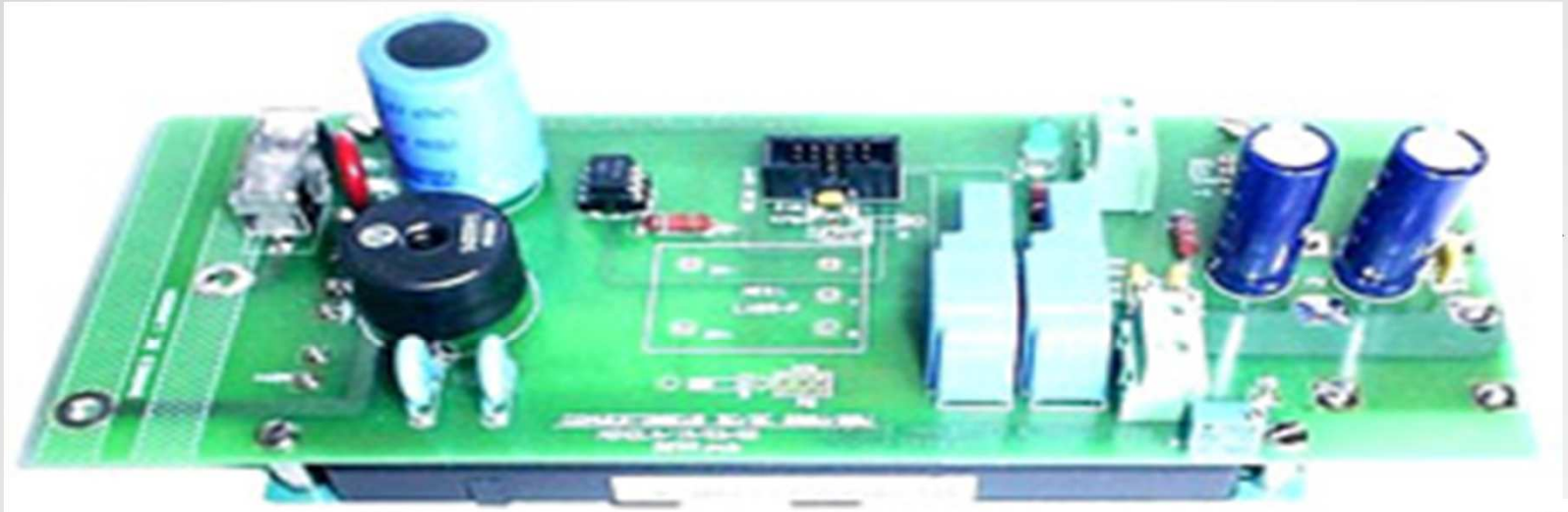


# G & η vs. output power



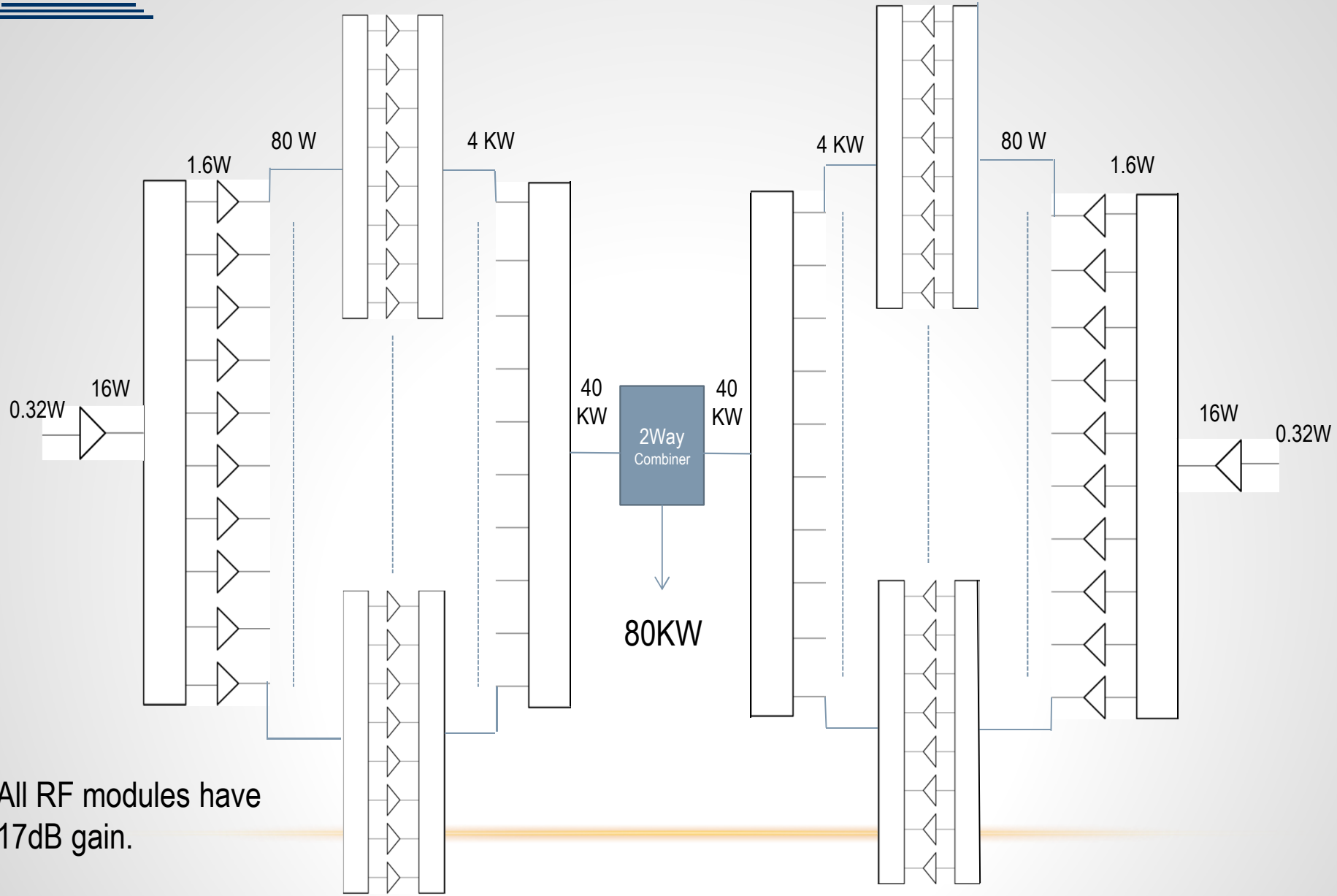







RF tower power supply will be implemented in SESAME; 220ACV-to-50VDC/2kW.

# SESAME 80KW tower Solid State Amplifier architecture




All RF modules have 17dB gain.

SESAME

## SOLEIL Storage Ring RF Solid State Amplifiers (SSA)

# SESAME Options for Cavity

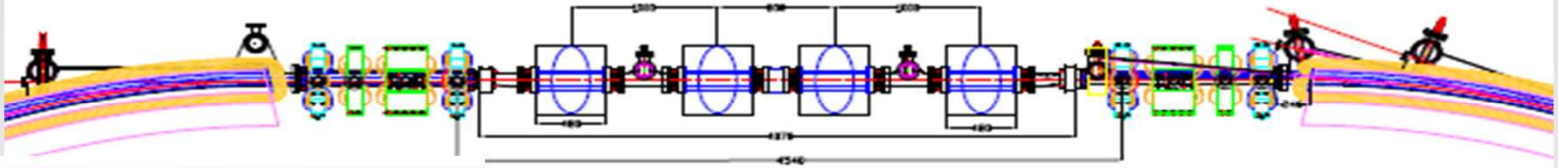
## SESAME SR RF Power Requirements:

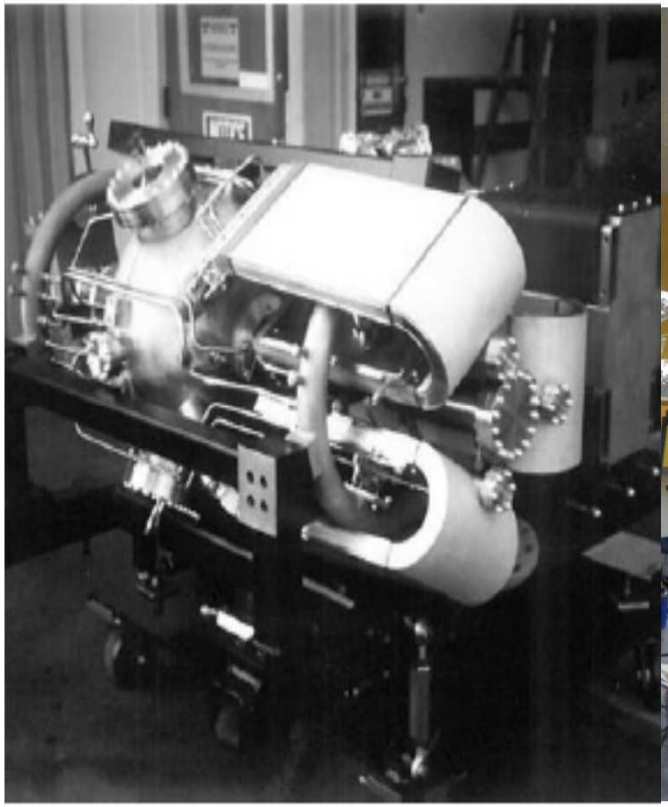
- Due to input power coupler limitations; the two donated Elettra cavity will be used mainly for the commissioning phase of the SR.
- Max. stored current will be around 40mA.
- To operate the SR at 2.5GeV/400mA with extra 80KeV due to ID's and 3 OVF would require each cavity to be able to handle 120KW.

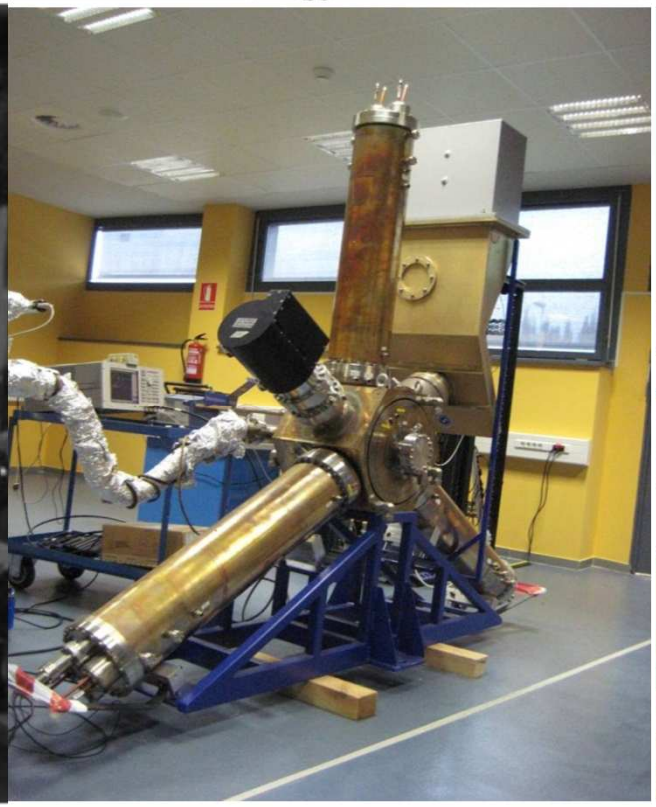
## SR Cavity Options:

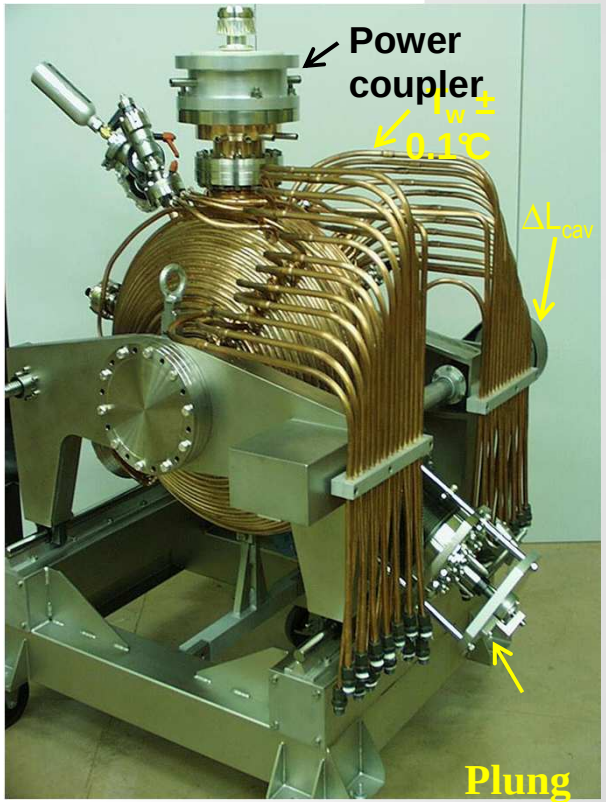
- EU: Used at many accelerators with very good HOM damping properties.
- KEK-PF: Very good option manufactured by Toshiba and we have doubts it might be expensive.
- Elettra cavity with the new I/P coupler design: Used at many accelerators too with temperature HOM shifting techniques.
- PEP2 cavity: An option that we believe to be very expensive one.

# SESAME SR RF Cavities










Phase2: Chosen cavities should be capable to compensate the energy losses of about 670KeV@400mA

Phase1: 2Elettra cavities with 60KW.max I/P Coupler

# SESAME RF GROUP

Darweesh FOUDEH

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# Thank You